ADDENDUM A

Chapter 15

The Design of Flat and Long Products Casters

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15.1 Introduction

The last two decades of the twentieth century saw a dramatic advance in the design of continuous casting machines. In that time, the design capacity of a typical continuous casting strand virtually doubled, yet the capital investment cost did not increase in the same way, which means that the real investment cost per ton of capacity declined.

This improvement was achieved due to a whole range of factors, including:

- An increased process understanding.
- The application of newer and advanced materials such as coatings for molds and rolls.
- The increased reliability of standard proprietary components such as bearings and electrical control equipment.
- Increased automation by the application of many more sensors, actuators, control models and software.
- Attention to the elimination/reduction of casting interruptions.
- The application of more efficient designs due to the use of more sophisticated and rigorous design methods such as finite element (FE) and computational fluid dynamics (CFD) analysis. Such progress has only been possible due to the improvement in computing power.

One of the factors in increasing capacity has been the gradual increase in casting speeds, this in turn has led to the possibility to reduce the number of strands for a given production requirement. Today, for instance, a single-strand slab caster is applied where a two-strand caster was applied in the early days; billet/bloom machines also generally have fewer strands. Reducing strands reduces not only capital costs but also operational costs.

The continuous casting process, being the liquid-to-solid phase change operation, is the pivotal step in achieving good quality steel processing. Continuous casting machine design is an arena where the various disciplines of metallurgy, mechanical, electrical, control and fluids engineering have to collaborate perhaps more closely than any other in the steel processing route so that the outcome may be successful. Many of the major technologies resulting from those disciplines are embodied in today's sophisticated casters.

Since the early industrialization of continuous casting, there has been a gradual proliferation of machine types tailored to serve particular end uses. This makes continuous casting design all the more varied and exciting.

This chapter deals mainly with continuous casting machine design in relation to conventional thick/medium slab casting and bloom/billet casting. Much of what is described relates to some extent to other nonsynchronous casting processes (those where the mold, although oscillating, is on average stationary in relation to the moving strand) such as thinner slab casting. It does not relate to the synchronous strip casting process where rotating mold rolls are applied.

15.2 Types and Anatomy of Continuous Casting Machines

15.2.1 Types of Casting Machines

Over recent years, the number of different types of continuous casting machines has proliferated as the technology has been applied in new areas that in turn address specific markets.

It is a simple matter to differentiate between flat products, which are derived from slabs, and long products, which are derived from bloom and billets. A width-to-thickness aspect ratio of 2.5 to 1 could be taken as the division between flat and long products.

For bloom and billet casting, there is the range of rectangular/square sections, as shown in Fig. 15.1, as well as beam blanks, which are also shown. Additionally, rounds can replace the squares,

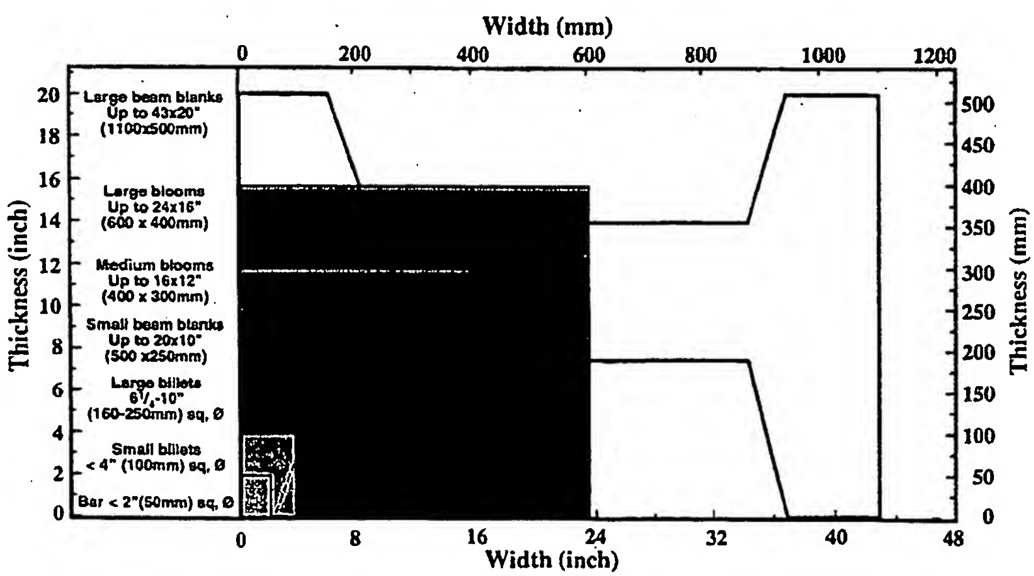

Fig. 15.1 Range of long product cast section sizes.

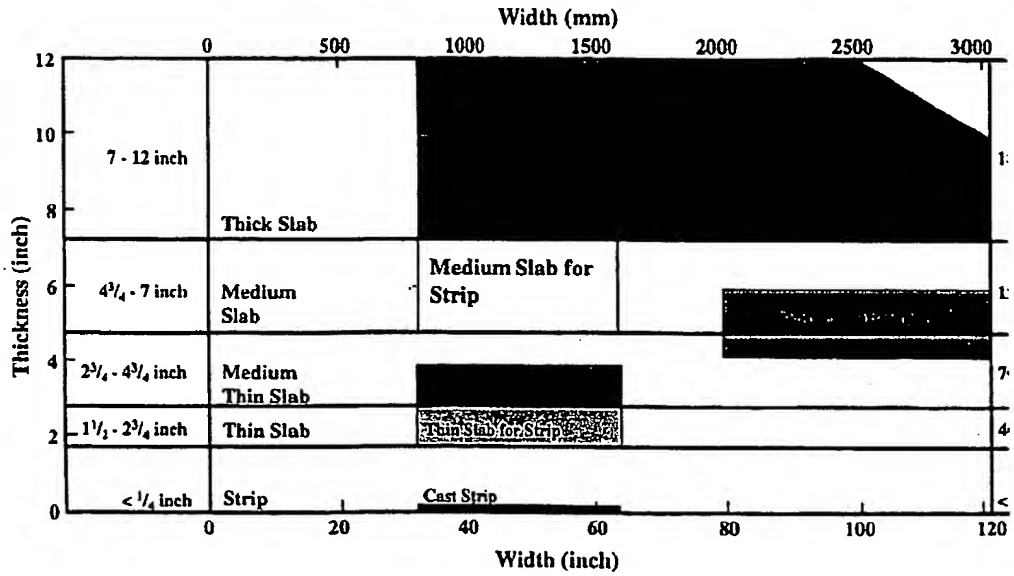

Fig. 15.2 Range of flat product cast slab section sizes.

and there is also a niche for low-volume casting of very small rods and wire. While a large bloom caster can look very different in scale to a small billet caster, the general principles still apply.

For slab casting, the technology has expanded to nearer net shape areas such as thin slab casting, wide plate grade casting and the newly emerging strip casting (see Fig. 15.2).

In addition to dedicated long or flat products casters, combination casters give operators an extra degree of flexibility. In these cases, long products and/or narrower slabs can be cast down slab strands, usually in multiple strands. Fig. 15.3 gives one such example.

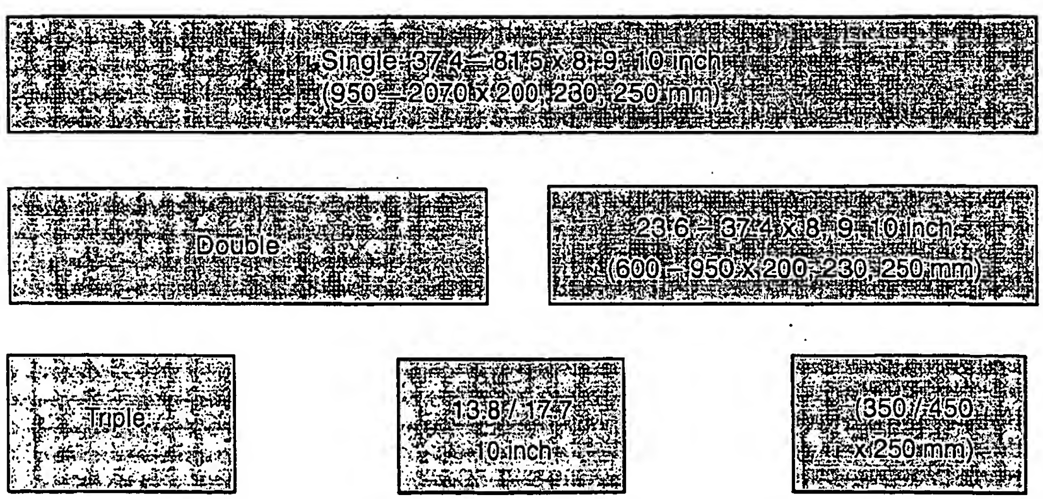

Fig. 15.3 Combination casting at BHP Whyalla.

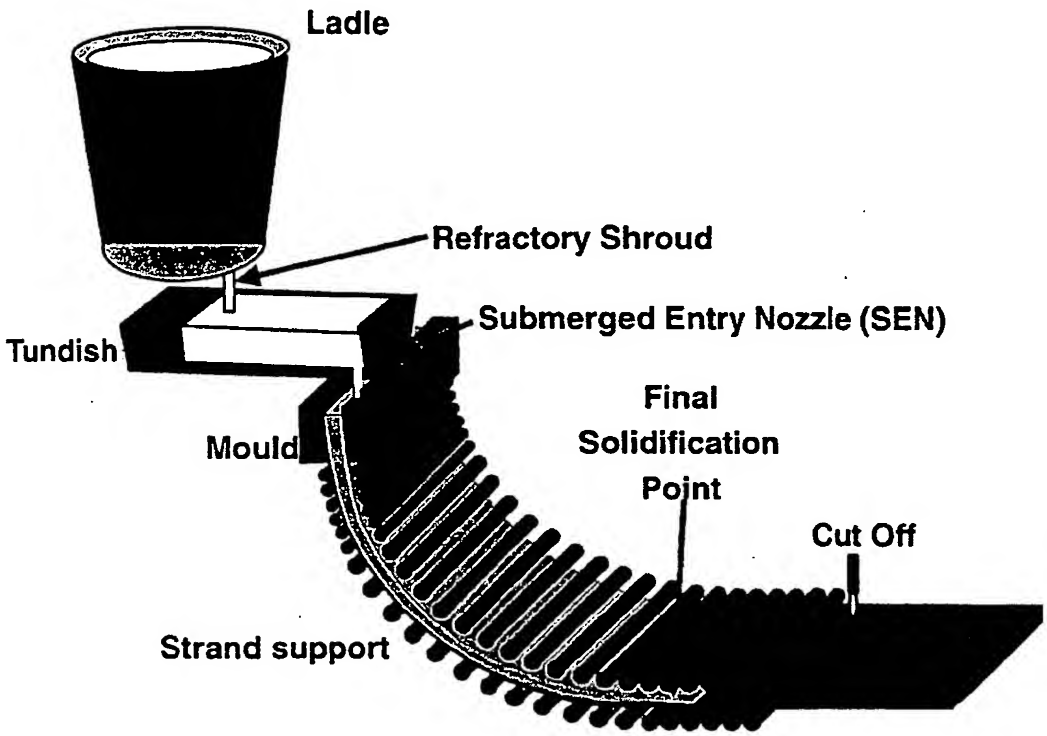

Fig. 15.4 Continuous casting principal parts and process elements.

15.2.2 Basic Caster Process Equipment

The principal parts and process elements of the continuous casting machine are shown in Fig. 15.4 and include the following:

- Ladle: Batch supply of steel to the caster up to 350 tons at a time.
- Tundish: Reservoir of steel that provides a constant supply of steel to the mold, even during ladle changes.
- Mold: Water cooled copper plates that dictate the size and shape of the product. Solidification in the mold is often referred to as primary solidification.
- Strand Support and Cooling: Rolls that support and sprays that cool the solidifying shell and maintain product shape by resisting ferrostatic pressure (that is, the pressure due to the head of liquid steel in the strand). Solidification in this region is often referred to as secondary solidification.
- Final Solidification Point: Point at which the very center of the cast product finally goes fully solid.

15.2.3 Continuous Casting Machine Anatomy

A more detailed anatomy of the continuous casting machine is shown for billet casting in Fig. 15.5, and slab casting in Fig. 15.6.

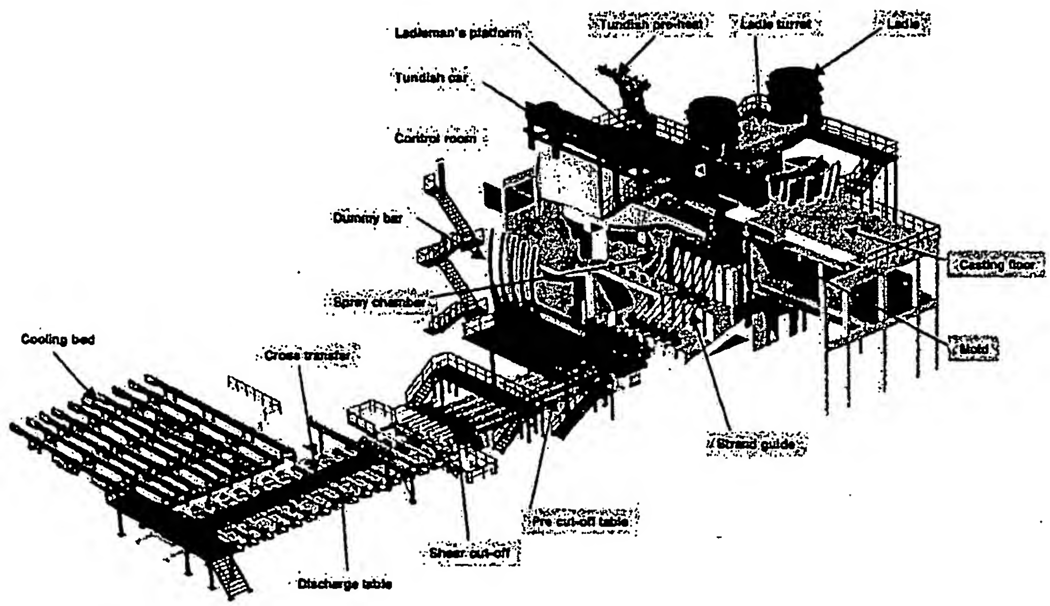

Fig. 15.5 Billet casting machine anatomy.

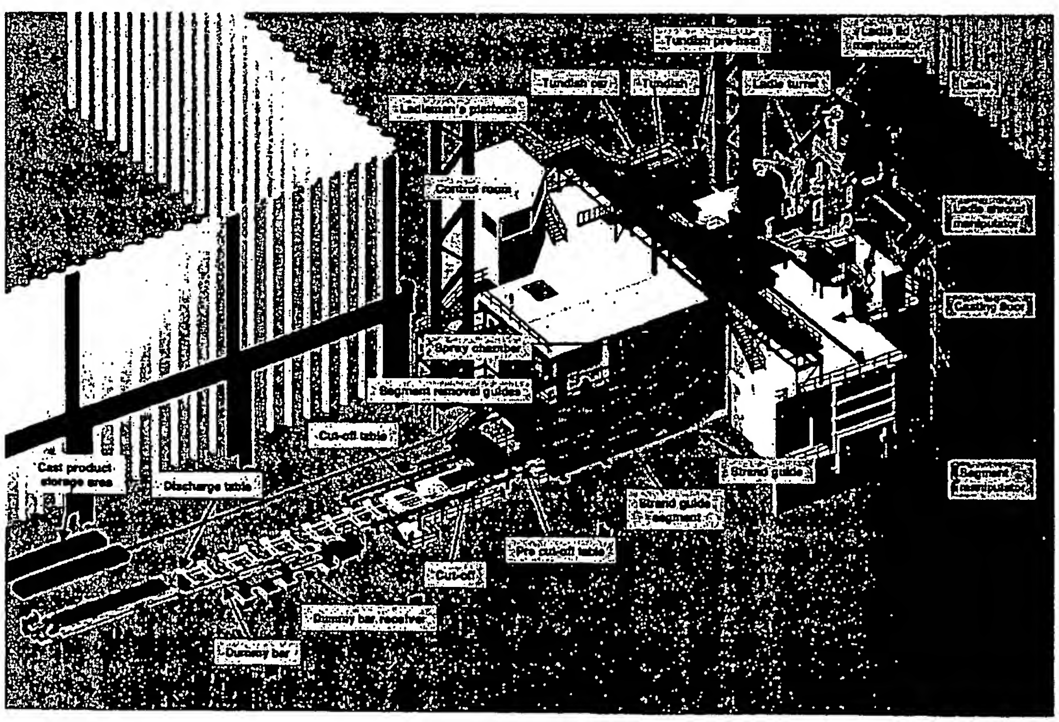

Fig. 15.6 Slab casting machine anatomy.

Chapter 5

Modeling of Continuous Casting

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The high cost of empirical investigation in an operating steel plant makes it prudent to use all available tools in designing, troubleshooting and optimizing the process. Physical modeling, such as using water to simulate molten steel, enables significant insights into the flow behavior of liquid steel processes. The complexity of the continuous casting process and the phenomena which govern it, illustrated in Figs. 5.1 and 5.2, make it difficult to model. However, with the increasing

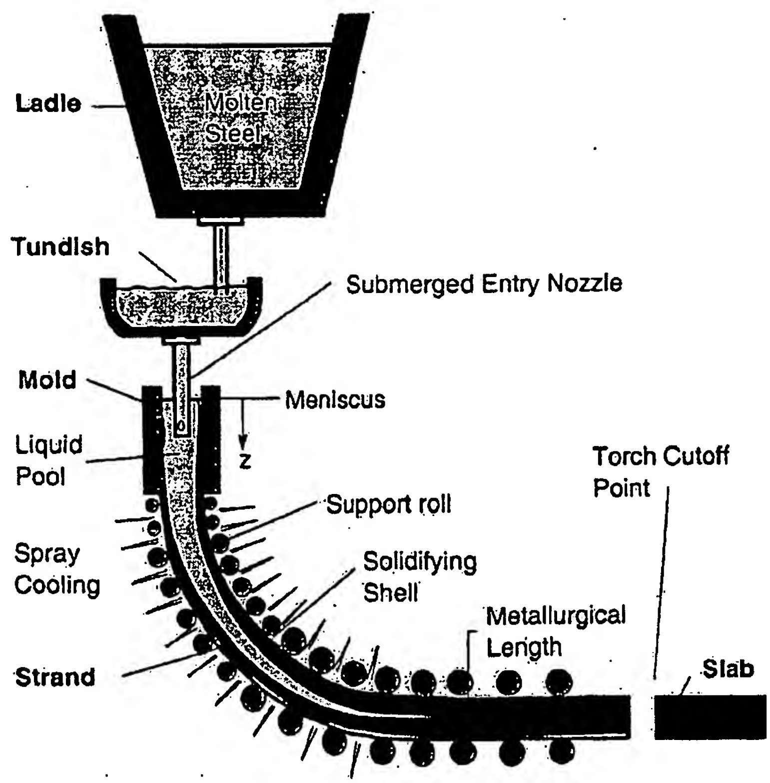

Fig. 6.1 Schematic of continuous casting process.

